Numb. 120

PHILOSOPHICAL TRANSACTIONS.

December 27. 1675.

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New Experiments about the weaken'd Spring and ſome un-obſerv'd Effects of the Air: Made and communicated by the Honourable Robert Boyle *Eſq.*

—— AS for the not yet communicated Tryals that I made in proſecuting my Deſign of diſcovering or obſerving ſome *latent* Qualities of the *Air*, I will not deny you ſome of them, as imperfect as they yet are, but will venture to ſend them you, as my Notes or my Memory ſuggeſts them to me; not only, becauſe without being compleated they may be fit enough to countenance *ſuſpicions* (for you know,that I do not call them ſo much as *opinions*,) but for a weightier inducement, to be told you at the end of this Paper.

The two chief things aimed at in the imperfect Attempts I now ſend you, were to diſcover; *firſt*, whether, as ſome Corroſions of Bodies do in cloſe Veſſels *increaſe* the Spring of the Air (as I long ſince noted them to do,) ſo ſome other Corroſions may not, by a contrary or ſome other way, *weaken* the Spring of the Air; and *next*, whether in ſome Solutions and Precipitations the Air on the account of ſome unobſerved Quality may not be found to produce ſome *Phænomena* not yet taken notice of.

In order to each of theſe Enquiries, I ſhall mention a few Tryals, though without curiouſly ſorting them, becauſe ſometimes in the ſame Experiment both thoſe Attempts were jointly proſecuted.

You may remember that in ſome of my formerly publiſhed Tryals I acquainted you with an odd *Phænomenon* of the *Change* of *Color* producible in ſolutions of *Copper* by the operation of the Air; I ſhall now add what further *Phænomena* my Memory or Notes ſupply me with, about the Subject of that and the like Experiments.

Experiment the Firſt.

We took filings of crude Copper, and put them into a Cryſtallin Glaſs of a Conical ſhape, into which we poured ſome ſtrong Spirit of Salt, (that was fitted for our peculiar purpoſe) to the heighth of about a fingers breadth above the Filings; and then cloſing the Veſſel with a Glaſs-ſtopple exquiſitly fitted to it, we ſuffer'd it to continue unmoved in a Window for ſome dayes, till the liquor had both obtained a high and darkiſh brown colour by the ſolution of ſome of the Copper, and loſt that colour again, growing clear like common water, (which is it ſelf a ſomewhat odd Phænomenon;) and then taking out the ſtopple, (without ſhaking the liquor) and thereby giving acceſs to the outward Air, we perceived, (as we had conjectur'd) that the upper ſurface of the liquor did in a few minutes re-acquire a darkiſh brown colour, which penetrating deeper and deeper, at the end of about a quarter of an hour the whole body of the liquor appear'd to be likewiſe tinged. The Conical Glaſs being again well ſtopt, the *Menſtruum* did again in very few daies let fall or otherwiſe loſe its tincture; which, the ſtopple being taken out, it re-gained as before. Nor were theſe two the only Tryals I made with the like ſucceſs for the main; but afterwards being deſirous by a further Tryal to reſolve a doubt I had, I kept the Glaſs yet longer in the ſame place with the ſame Filings and *Menſtruum* in it for (if I miſ-remember not) a moneth or two together; but obſerved not, that the liquor would any more grow clear.

Experiment the Second.

Having taken ſuch a Glaſs, as is mention'd in *Experiment the firſt*, wherein the liquor was grown clearer than is uſual, and had probably been ſo a good while before, (for the Veſſel, having been hid by others which ſtood before it, had been for ſome weeks forgotten;) We took out the ſtopple and left it open for about half an hour, but did not perceive the liquor to have acquired any colour ſo much as at the top. Whether this proceeded from the long debarring of commerce with the freſh Air, or from ſome other cauſe, being unable to wait the event as long as would perhaps be requiſite, I thought fit to try, Whether the Air had already had ſome operation upon the liquor, though it did not yet appear; and accordingly putting in the ſtopple, I left the Veſſel cloſed for two or three hours, and at my return to viſit it, I perceived, that it had acquired a faint colour tending to a *green*; wherefore taking out the ſtopple again, I open'd its Commerce with the outward Air, leaving the Glaſs unſtopt for 20 or 24 hours, but found, that in all that time it had not re-gained its wonted dark colour, but was only arrived at a green, deep enough, but not true nor very tranſparent.

This Obſervation being made in the ſame Veſſel that had been formerly employed, ſuggeſted to us an Enquiry, Whether the advanced time of the year, which was the middle of *October*, might not have an intereſt in the ſlow and imperfect ſucceſs of this Tryal.

Experiment the Third.

Some ſtrong Spirit of Salt having been kept upon Filings of Copper till the ſolution was come to be of a dark brown colour, about three ſpoonfuls of it by gueſs was put into a Receiver that might hold eight or ten times as much: Being kept *in vacuo* (if the time be rightly remember'd) about half a year, it retain'd its colour, but the Veſſel being open'd and the External Air permitted a free acceſs to it, the ſolution in about an hour was turn'd into a fine tranſparent green, though no Precipitation of any muddy ſubſtance appeared by any Sediment to be made.

Experiment the Fourth.

In one of that ſort of Conical Glaſſes that has been already more than once deſcrib'd, we had put upon ſome Filings of Copper a convenient quantity of our *Spirit of Salt*; and though we obſerv'd, that for a great while it would not part with its deep and ſomewhat muddy tincture; yet we left it in the window for many weeks longer, and at length, towards the latter end of *December*, we found it to have loſt its tincture, ſo much that the liquor appear'd like common water. Upon which obſervation, though the time of the year were unpromiſing, I thought fit to try, whether the Air in that ſeaſon would not have ſome, though perhaps but a ſlow, operation on the Saline Spirit, and accordingly taking out the Glaſs-ſtopple to give free acceſs to the outward Air; we obſerv'd, that in ſome hours its operation on the liquor was ſcarce ſenſible, but within about 24 hours the *Menſtruum* had acquired not juſt its former colour, but a ſomewhat faint and moderately tranſparent green: So that this tincted *Menſtruum*, as it had been very ſlow in loſing its colour, ſo it did but ſlowly and imperfectly re-acquire it.

I *Have not in the foregoing Experiments made mention of any Phænomena of them relating to the* Spring *of the* included Air, *becauſe I do not remember, that they were ſuch as invited me to draw any poſitive Concluſion from them, and my ſilence on this occaſion may be the more allowable, becauſe the way of further making ſuch Obſervations may be ſufficiently deduc'd from the inſuing Tryals; in reciting of which I alter very little, and in ſome of them not at all, the expreſſions I find them regiſter'd in, though more than once the* Phænomena *that relate to the Air's Elaſtic power be mingled in the ſame Experiment with the mention of its operations upon Colours.*

The Spring of the Air and its variations, by the wayes now known to many of the Curious, being things that manifeſtly appear to have a notable intereſt in divers Phænomena of Nature, whoſe Cauſes, *if not* themſelves *alſo, were unknown to former Philoſophers; it ſeem'd an Attempt, though not very promiſing, yet worth the making, to try whether the Spring of the Air, which may divers wayes, as by Heat, Compreſſion, &c. be increas'd, may not by ſome other way than Cold and Dilatation be weaken'd: And having often found Menſtruums that corrode Metals, ſo as to produce* bubbles *to invigorate the ſtrength*

of

of the Spring of the Air included in the Veſſels, wherein the ſolution was made, I thought fit to try, whether in ſome metalline Diſſolutions, wherein I had obſerved that few or no *viſible* bubbles *at all were produced, the Spring of the neighbouring and included Air would not be debilitated; and in order to this were made the following Tryals.*

Experiment the Fifth.

[WE took ſome Filings of Copper, and putting them together with a *Mercurial gage* * in a Conical Glaſs fitted with an exactly ground ſtopple of the ſame matter, (which was Cryſtalline) we poured on the Filings as much rectified *Spirit of fermented Urin* made *per ſe*, as ſufficed to ſwim an inch or better above them; then carefully ſtopping the Glaſs, coming to look on it many hours after, we perceived that the Mercury in the ſeal'd leg was conſiderably depreſt, and gently drawing out the ſtopple to let in the outward Air, we perceived that acceſs to have a manifeſt effect upon the Mercury.]

* About ſuch Glaſſes ſee *Experiment the Seventeenth* in the Continuation of our New Phyſico-Mechanical Experiments.

But this will be better underſtood by the more Circumſtantial Experiment that inſues.

Experiment the Sixth.

[We took a Cryſtal Glaſs of an almoſt Conical ſhape, and capable of containing between five and ſix ounces of water, and furniſhed with a ſtopple of the ſame matter, that by grinding was exactly fitted to it. Into this we put a convenient quantity of clean Filings of good Copper, on which we poured as much ſtrong Spirit of (fermented, or rather) putrifi'd Urin, as ſerved to ſwim about an inch above the Copper, and having let down a Mercurial gage, ſo that it leaned upon the bottom and ſide of the Glaſs, we cloſed it very well with a ſtopple, and ſet it in a quiet and well enlighten'd place, having taken good notice at what mark the Quickſilver reſted in the open leg of the Gage. This done, we let the *Menſtruum* alone to work upon the Filings; which it did, as we foreſaw, ſomewhat ſlowly and very calmly *without* producing any noiſe or ſenſible bubbles, acquiring by degrees a very pleaſant blew colour, and the Glaſs being kept quiet in the ſame place for two or three daies longer, the liquor, as I conjectur'd

See the reference in the foregoing Experiment.

would happen, began to loſe of the intenſneſs of its colour, which by degrees grew fainter and fainter, till at the end of three or four daies the liquor was grown very pale, and left me little doubt but that, if I would have ſtaid ſome daies longer, it would have loſt the remaining Eye of blew, and have lookt almoſt like common water. But being unwilling to tarry ſo long, I took out the ſtopple, that the Air *without* the Glaſs might have acceſs to that *within*; and leaving the Vial in the ſame place and poſture, my expectation was ſomewhat anſwer'd by finding, that within four or five minutes, if not leſs, the upper part of the liquor, that was contiguous to the Air, had acquired a fine blew colour, which deſcending deeper and deeper, before the end of the tenth minute had diffuſed it ſelf, but ſomewhat weaken'd, through the liquor, whoſe colour was ſuffer'd to deepen for a while longer; ſo that in leſs than a quarter of an hour from the firſt unſtopping of the Vial, the liquor was grown to be throughout of a rich Ceruleous colour, which grew almoſt too opacous within a few minutes longer: When carefully cloſing the Vial again with the ſame ſtopple as before, we ſet it aſide in the ſame place, where, the included Air being denied all Commerce with the External, the liquor began again within two or three daies to loſe of its colour; and, to be ſhort, afforded me the opportunity of making a *ſecond* Experiment, much like the former. And the like ſucceſs I had, for the main, in a Tryal or two made in another Glaſs with another portion of the ſame Spirit of Urin, put upon the Filings of Copper; ſo that the Experiment was, in all, made divers times, as well when I was not, as when I was alone: And particularly, once to be ſure that the *diurnal* Air as ſuch had not any great intereſt in the *Phænomenon*; I made the Tryal ſucceſsfully about Nine a clock at night in the preſence of ſo well-known a Witneſs as the Learned Secretary of the *Royal Society.*

One Circumſtance I forgot to take notice of, which was, that in moſt of theſe Experiments I forbore to ſhake the Glaſs, leſt it ſhould be ſuſpected, that the Agitation of the liquor might have raiſed ſome little fine powder that might have been ſuppoſed to have been precipitated out of the tincture, and, being thus mingled with the liquor again, reſtore it to its former colour; but in truth I did not perceive any ſuch powder to be precipitated. And though, to obviate the objection, I forbore to ſhake the Vial; yet

yet I juſtly ſuppoſed, that if, by the agitation of the liquor, more parts of it ſhould be quickly expoſed to the action of the Air, the Coloratiou would be haſten'd, which upon tryal appear'd to be true.]

Experiment the Seventh.

[Experience having made me think it likely, that ſtrong *Spirit* of *Sal Armoniac*, made without Quick-lime, would operate more nimbly and more powerfully on that metal than our Spirit of Urin had done; we took ſuch a Conical Glaſs, as has been lately deſcribed, and covering the bottom of it with a convenient quantity of Filings of good Copper, we poured on them as much ſtrong Spirit of *Sal Armoniac* as ſerved to ſwim about a fingers breadth above them; and, having let down ſuch a Mercurial Gage as is formerly mention'd, ſo that it leaned upon the bottom and ſide of the Glaſs, we cloſed it very well with a ſtopple and ſet it in a quiet and well enlighten'd place, having taken good notice at what mark the Quickſilver reſted in the open leg of the Gage: This done, we let the *Menſtruum* alone to work upon the Filings, which it did, as we foreſaw, ſomewhat ſlowly and very calmly, without producing any noiſe or ſenſible bubbles, acquiring by degrees a very pleaſant blew colour, and afforded us alſo the Phænomenon we chiefly lookt after; which was, that repairing from time to time to the window to ſee what paſt, we perceived, that for two or three daies together the Mercury in the ſeal'd leg of the *Gage* did, though very ſlowly, deſcend till it appear'd to be near a quarter of an inch lower than at firſt; and probably the depreſſion might have been greater, if ſome indiſcreet body or other had not, by tampering with the Glaſs, diſturbed the Experiment; whoſe event yet ſeemed ſufficiently to argue, that the Spring of the Air, contained in the cavity of the Glaſs, and communicating with that in the open leg of the Gage or Syphon, was weaken'd in compariſon of that in the cloſed leg, which by the Hermetic Seal on one ſide, and the Quickſilver on the other ſide, was kept from ſuch Communication.

And becauſe I thought, it might be ſuſpected, that the Phænomenon might be referrable to ſome Inequality in the preſſure of the Air, occaſioned by the greater operation of the heat of the day on the more impriſon'd Air of the Gage, than on that more immediately included in the cavity of the Vial; I was careful to obſerve, whether the Depreſſion did not continue at differing times of the day, and found it to do ſo, as well at night as at noon, though at this laſt named time the Sun ſhined hot upon the place and Veſſels too.

This Experiment was made, in all, four or five times, though not alwaies with equal, yet ſtill with ſome, ſucceſs, the Mercury in the ſeal'd leg of the Gage being ſometimes more and ſometimes leſs, but alwaies manifeſtly depreſt; which Phænomenon was confirmed by the Obſervation we more than once made of the ſudden return of the Quickſilver to it former ſtation, upon the unſtopping of the Glaſs, to give free admiſſion to the outward Air.

Experiment the Eighth.

Conſidering, whilſt I was about theſe Tryals, that *Spirit* of *Vinegar*, though in working upon Coral and ſome other Bodies it not only produces ſtore of bubbles, but alſo, as I have elſewhere deliver'd *, a ſomewhat odd kind of Elaſtical Subſtance, yet being put upon *Minium* it was wont, in my Obſervation, to work calmly and without producing froath; I thought fit to make tryal, whether this calm and ſilent ſolution of *Minium* would be accompanied with a permanent change of the Airs Spring: The Event I find thus ſet down:

[A pretty quantity of *Spirit* of *Vinegar* being put upon *Minium* in a Conical Glaſs, furniſhed with a Glaſs ſtopple and a Mercurial Gage, continued divers dayes without any ſenſible Depreſſion of the Mercury in either leg, nor did any change appear in the

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* To the better underſtanding of this, the enſuing Tryal may much conduce; and therefore is tranſcribed out of another paper, to which it properly belongs.

A Mercurial Gage having been put into a Conical Glaſs whoſe bottom was covered with beaten Coral, ſome Spirit of Vinegar was poured in, and then the Glaſs ſtopple, which was very well ground, cloſing the neck exactly, we obſerved, that upon the working of the Menſtruum on the Coral, ſtore of bubbles were for a good while produced, which ſucceſſively broke in the cavity of the Veſſel, and their acceſſion ſo conſtipated the Air, that they compreſt the Air impriſon'd in the cloſed leg of the Gage three marks or Diviſions, which I gueſſed to amount to about the third part of the extent it had before: But ſome hours after the Corroſion had ceaſed, the Compreſſion made by this newly generated Air grew manifeſtly fainter, and the impriſon'd Gage-Air drove down the Mercury again 'till 'twas depreſt within one diviſion of its firſt ſtation; and thereabouts, or little lower, continued five or ſix dayes; ſo that in this operation there ſeemed to have been a double Compreſſive Power exerciſed; the one *tranſient*, by the briſk agitation of Vapours or Exhalations, and the other *durable*, from the Aerial and Springy Particles, either produced or extricated by the action of the Spirit of Vinegar upon the Coral.

the *Gage*, upon the removal of the ſtopple, though 'twas evident by the great ſweetneſs acquired, that it had made a Solution of a great portion of the *Minium.*]

But to return to our Tryals upon Copper ;

Experiment the Ninth.

[We took ſome Filings of Copper, and in a Vial capable of holding ſome two or three Ounces of Water, we poured on them ſtrong *Spirit* of *Sal Armoniac* made without Quicklime, till the liquor reached near an Inch above them. This was done about the twentieth of *Auguſt* on the *Friday* before Noon, and the following *Munday* preſently after Dinner it had acquired a deep Blew tincture, and loſt again ſo much of it, that 'twas pale almoſt like common water: Then to ſatisfie a *Virtuoſo*, I unſtopt the Vial, deſiring him to place his eye level with the ſurface of the liquor, which in a minute of an hour or leſs appeared, to his ſurprize and wonder, to have acquired a deep Blew tincture, that reached downwards to the thickneſs of the back of a knife, the whole liquor becoming of the like Colour in four or five minutes more, and the Glaſs being preſently ſtopt again, and left where 'twas before, appeared not at the end of nine daies to have loſt its tincture; though now and then within that time it ſeemed manifeſtly paler than when the Vial was ſtopt.]

None of the former Tryals with Spirit of Sal Armoniac having been made in an Hermetically ſealed Glaſs, it will not be amiſs both to diverſifie and to confirm our Experiments, by ſetting down the ſucceſs of one made in ſuch a Veſſel:

Experiment the Tenth.

[We took a round Vial holding about eight Ounces of water, and having put into it Filings of Copper and a Mercurial Gage, we poured on the Metal ſtrong Spirit of Sal Armoniac, till it reached to a good height in the Vial, which then being Hermetically ſealed up, was ſet by in a South-window, where it quickly ac-

quired

quired a deep Blew tincture: There it ſtood about twelve daies, before that tincture, which decayed but ſlowly, did little by little grow ſo diluted that the liquor was pale and almoſt like water: During this ſtay of the Glaſs in the window, the Mercury in the open leg appeared to be impell'd up, and when after nine a clock at night, (which time I choſe to try whether the Nocturnal Air, as Nocturnal, would have any thing to do with the Phænomenon,) the Hermetic Seal was broken off; immediately upon which there was produced a noiſe, and the Mercury in the ſhorter and cloſed leg was briskly impell'd up, by our gueſs, near three eights of an Inch, and though the Orifice at which the Air had acceſs was ſcarce wide enough to admit a middle ſeized pea, yet within a minute and half the ſurface of the liquor being held between the Eye and the Candle, appeared to have acquired a very lovely and fair Colour, which reached downwards a quarter of an Inch; ſo that the Vial ſeemed to contain two very differing liquors ſwimming on one another, and the Coloration piercing deeper and deeper within five Minutes in all, the whole liquor had attained a rich Blew colour.]

With this Experiment I ſhall conclude this Paper: For, though I made ſeveral other Tryals, with the ſame deſign that I made the foregoing ones, as with Spirit of Niter, *and* Minium, Spirit of Vinegar *and* Copper; *yet a preſent want of time hinders me from troubling you with them, which I the rather forbear to do, becauſe I fear, they would prove leſs ſatisfactory than thoſe I have ſet down; which themſelves muſt, to a leſs diſcerning eye than yours, appear very imperfect, notwithſtanding that prolixity in reciting ſome of them; which I was obliged to by my not yet knowing, in ſuch odd attempts, what Circumſtances might ſafely be omitted. But ſuch as they are I ſend them you, who by your diffuſed Correſpondency have great opportunity to get them made, if you think them worth it, by Curious perſons in ſeveral Countries, various manners, and differing ſeaſons of the Year: And, however the things I ſend you be but trifles, yet their Novelty may perhaps excite the Induſtry of others, and give riſe to further Inquiries.*